

FEDERAL AVIATION AGENCY

Washington 25, D. C.

TECHNICAL STANDARD ORDER

Regulations of the Administrator

Part 514

SUBJECT: ELECTRIC TACHOMETER: MAGNETIC DRAG
(FOR AIR CARRIER AIRCRAFT)

TSO-C49a

Technical Standard Orders for Aircraft Materials,
Parts, Processes, and Appliances

Part 514 contains minimum performance standards and specifications of materials, parts, processes, and appliances used in aircraft and implements the provisions of sections 3.18, 4a.31, 4b.18, 6.18 and 7.18 of the Civil Air Regulations. The regulation uses the Technical Standard Order system which, in brief, provides for FAA-industry cooperation in the development of performance standards and specifications which are adopted by the Administrator as Technical Standard Orders, and a form of self-regulation by industry in demonstrating compliance with these orders.

Part 514 consists of two subparts. Subpart A contains the general requirements applicable to all Technical Standard Orders. These provisions are summarized below for the convenient reference of the public. Subpart B contains the technical standards and specifications to which a particular product must conform, and each Technical Standard Order is set forth in the appropriate section of Subpart B. The subject Technical Standard Order is printed below. ANY TECHNICAL STANDARD ORDER MAY BE OBTAINED BY SENDING A REQUEST TO FAA, WASHINGTON 25, D. C.

SUBPART A--GENERAL

This subpart provides, in part, that a manufacturer of an aircraft material, part, process, or appliance for which standards are established in Subpart B, prior to its distribution for use on a civil aircraft of the United States, shall furnish a written statement of conformance certifying that the material, part, process, or appliance meets the applicable performance standards established in this part. The statement of conformance must be signed by a person duly authorized by the manufacturer, and furnished to the Chief, Engineering and Manufacturing Division, Bureau of Flight Standards, Federal Aviation Agency, Washington 25, D. C.

Subpart A also requires appropriate marking of materials, parts, processes, and appliances as follows:

- (a) Name and address of the manufacturer responsible for compliance,
- (b) Equipment name, or type or model designation,
- (c) Weight to the nearest pound and fraction thereof,
- (d) Serial number and/or date of manufacture, and
- (e) Applicable Technical Standard Order (TSO) number.

In addition, Subpart A provides that no deviation will be granted from the performance standards established in Subpart B, and that the Administrator may take appropriate action in the event of noncompliance with Part 514.

SUBPART B

§ 514.48 Electric tachometer: magnetic drag (for air carrier aircraft) - TSO-C49a--(a) Applicability--(1) Minimum performance standards. Minimum performance standards are hereby established for electric tachometers which specifically are required to be approved for use on civil aircraft of the United States. New models of electric tachometers manufactured for installation on civil aircraft on or after October 15, 1960, shall meet the standards set forth in SAE Aeronautical Standard AS-404B, "Electric Tachometer: Magnetic Drag (Indicator and Generator)," dated February 1, 1959,^{1/} with exceptions, additions, and substitutions to the standards listed in subparagraph (2) of this paragraph.^{2/} Electric tachometers approved by the Administrator prior to October 15, 1960, may continue to be manufactured under the provisions of their original approval.

(2) Exceptions. (i) The following specifically numbered parts in AS-404B do not concern minimum performance and therefore are not essential to compliance with this section: Parts 3.1, 3.1.1, 3.1.2, 3.2, 3.2(a)(b)(c)(d)(e)(f), 4.1.3.1, 4.1.3.2, 4.1.3.3, 4.1.3.4, and 4.1.3.5.

(ii) In lieu of part 7. in AS-404B, it is a requirement that tachometers covered by this section be capable of successfully passing the tests in parts 7.1 through 7.8.

(b) Marking. In addition to the markings specified in Subpart A, range and rating shall be shown.

(c) Data requirements. (1) The manufacturer shall maintain a current file of complete design data.

(2) The manufacturer shall maintain a current file of complete data describing the inspection and test procedures applicable to his product. (See paragraph (d) of this section.)

(3) Six copies each of the following shall be furnished to the Chief, Engineering and Manufacturing Division, Bureau of Flight Standards, Federal Aviation Agency, Washington 25, D. C.

^{1/}Copies may be obtained from the Society of Automotive Engineers, 485 Lexington Avenue, New York 17, New York.

^{2/}When electric tachometers are installed on civil aircraft, the installation must comply with the functional and installational requirements of Parts 3, 4b, 6, or 7 of the Civil Air Regulations as applicable.

(i) Manufacturer's operating instructions and instrument limitations.

(ii) Drawing or photograph showing exploded view of instruments.

(iii) Installation procedures with applicable schematic drawings, wiring diagrams, and specifications. Indicate any limitations, restrictions, or other conditions pertinent to installation.

(d) Quality control. Each electric tachometer shall be produced under a quality control system, established by the manufacturer, which will assure that each tachometer is in conformity with the requirements of this section and is in condition for safe operation. This system shall be described in the data required under paragraph (c)(2) of this section. A representative of the Administrator shall be permitted to make such inspections and tests at the manufacturer's facility as may be necessary to determine compliance with the requirements of this section.

(e) Effective date. October 15, 1960.

ELECTRIC TACHOMETER: MAGNETIC DRAG (Indicator & Generator)

Issued 11/1/48
Revised 2/1/59

1. PURPOSE: To specify minimum requirements for Electric Tachometers primarily for use in reciprocating engine powered civil transport aircraft, the operation of which may subject the instruments to the environmental conditions specified in Section 3.3.
2. SCOPE: This Aeronautical Standard covers magnetic drag tachometers with or without built-in synchrosopes.
3. GENERAL REQUIREMENTS:
 - 3.1 Materials and Workmanship:
 - 3.1.1 Materials: Materials shall be of a quality which experience and/or tests have demonstrated to be suitable and dependable for use in aircraft instruments.
 - 3.1.2 Workmanship: Workmanship shall be consistent with high-grade aircraft instrument manufacturing practice.
 - 3.2 Identification: The following information shall be legibly and permanently marked on the instrument or attached thereto:
 - a. Name of Instrument
 - b. SAE AS 404B
 - c. Manufacturer's Part Number.
 - d. Manufacturer's Serial number or date of manufacture.
 - e. Manufacturer's name and/or trade mark.
 - f. Range.
 - 3.3 Environmental Conditions: The following conditions have been established as minimum design requirements. Tests shall be conducted as specified in Sections 5, 6 and 7.
 - 3.3.1 Temperature: When installed in accordance with the instrument manufacturer's instructions, the instrument shall function over the range of ambient temperatures shown in Column A below and shall not be adversely affected by exposure to the range of temperatures shown in Column B below:

<u>Instrument Location</u>	<u>A</u>	<u>B</u>
Powerplant Accessory Compartment	-30 to 70C	-65 to 100C
Heated Areas (temperature controlled)	-30 to 50C	-65 to 70C

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- 3.3.2 Humidity: The instrument shall function and shall not be adversely affected when exposed to any relative humidity in the range from 0 to 95% at a temperature of approximately 32C.
- 3.3.3 Vibration: When installed in accordance with the instrument manufacturer's instructions, the instrument shall function and shall not be adversely affected when subjected to vibrations of the following characteristics:

<u>Inst. Location in Airframe</u>	<u>Cycles Per Sec.</u>	<u>Max. Double Amplitude (Inches)</u>	<u>Max. Accel.</u>
Power Plant Mounted	5-150	.100	20 g.
Fuselage	5-500	.036	5 g.
Panel or Rack (Vibration Isolated)	5-50	.020	1.5 g.

- 3.3.4 Altitude: The instrument shall function and shall not be adversely affected when subjected to a pressure and temperature range equivalent to -1000 to 40,000 feet standard altitude, per NACA Report 1235, except as limited by the application of paragraph 3.3.1. The instrument shall not be adversely affected following exposure to an ambient pressure of 50 in. Hg absolute.
- 3.4 Radio Interference: The instrument shall not be the source of objectionable interference, under operating conditions at any frequencies used on aircraft either by radiation or feed-back, in electronic equipment installed in the same aircraft as the instrument.
- 3.5 Magnetic Effect: The magnetic effect of the indicator shall not adversely affect the operation of other instruments installed in the same aircraft.

4. DETAIL REQUIREMENTS:

4.1 Indicator:

- 4.1.1 Indication: Engine speed shall be indicated by means of one or more moving pointers or dials. Relative movement of the pointer with respect to the dial shall be clockwise for increasing RPM.
- 4.1.2 Dial Visibility: The pointers and all dial markings shall be visible from any point within the frustum of a cone whose side makes an angle of not less than 30° with the perpendicular to the dial and whose small diameter is the aperture of the instrument case. The distance between the dial and the cover glass shall be a practical minimum and shall not exceed 0.200".
- 4.1.3 Dial Markings:
- 4.1.3.1 Finish: Unless otherwise specified by the user, matte white material should be applied to all major graduations, numerals, and pointers. Non-functional surfaces should be a durable dull black.

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- 4.1.3.2 Graduations: All graduations shall be multiples of 10 RPM. The Increment between graduations shall not exceed 2-1/2% of full scale, above 600 RPM.
- 4.1.3.3 Numerals: Sufficient numerals shall be marked to identify positively and quickly all graduations.
- 4.1.3.4 Instrument Name: The designation "RPM", plus such other nomenclature as may be necessary, shall be legibly marked on the dial and may be of the same finish as the numerals.
- 4.1.3.5 Sealing: The indicator case may be either gasket sealed or hermetically sealed.
- 4.2 Generator: The generator shall be designed to operate in either direction of rotation and in any position.
5. TEST CONDITIONS:
- 5.1 Atmospheric Conditions: Unless otherwise specified all tests required by this Aeronautical Standard shall be conducted at an atmospheric pressure of approximately 29.92 inches of mercury and at an ambient temperature of approximately 25C and a relative humidity not greater than 85%. When tests are conducted with the atmospheric pressure or the temperature substantially different from these values, allowances shall be made for the variation from the specified conditions.
- 5.2 Vibration (to minimize friction): Unless otherwise specified all tests for performance may be made with the instrument subjected to a vibration of 0.002 to 0.005 inch double amplitude at a frequency of 1500 to 2000 cycles per minute. The term double amplitude as used herein indicates total displacement from positive maximum to negative maximum.
- 5.3 Vibration Equipment: Vibration equipment shall be used which will provide frequencies and amplitudes consistent with the requirements of Section 3.3.3 with the following characteristics.
- 5.3.1 Linear Motion Vibration: Vibration equipment for airframe structure-mounted or powerplant-mounted instruments or equipment shall be such as to allow vibration to be applied along each of three mutually perpendicular axes of the instrument.
- 5.3.2 Circular Motion Vibration: Vibration equipment for instruments located on the panel or rack (with shockmounts) shall be such that a point on the instrument case will describe a circle, in a plane inclined 45 degrees to the horizontal plane, the diameter of which is equal to the double amplitude specified.
- 5.4 Position: Unless otherwise specified, all tests shall be conducted with the instrument mounted in its normal operating position.

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6. INDIVIDUAL PERFORMANCE REQUIREMENTS: All instruments or components of such shall be subjected to whatever tests the manufacturer deems necessary to demonstrate specific compliance with this Aeronautical Standard, including the following requirements when applicable.

- 6.1 Scale Error at Room Temperature: The tachometer indicator shall be connected to its generator and the generator operated at the shaft speeds within the ranges specified in Table I. The scale error at any speed shall not exceed the values specified in Table I with the speed increasing or decreasing. When the speed is held constant at any point on the scale, the pointer shall not oscillate over a range greater than 20 RPM from 600 RPM to full-scale indication.

TABLE I

SCALE ERROR

<u>Gen. Drive Shaft Speed RPM</u>	<u>Correct Indicated Speed RPM</u>	<u>Scale Error Tolerance RPM</u>
300 - 1400	600 - 2800	25
1500 - 2250	3000 - 4500	40

- 6.2 Dielectric: Ungrounded instruments or grounded instruments prior to connection of the internal ground wire shall be tested by either the method of inspection of paragraph 6.2.1 or 6.2.2.

- 6.2.1 Insulation Resistance: The insulation resistance measured at 200 volts D.C. for five seconds between all electrical circuits connected together and the metallic case shall not be less than 5 megohms. Insulation resistance measurements shall not be made to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc., since this measurement is intended only to determine adequacy of insulation.

- 6.2.2 Overpotential Tests: Equipment shall not be damaged by the application of a test potential between electrical circuits, and between electrical circuits and the metallic case. The test potential shall be a sinusoidal voltage of a commercial frequency with an RMS value of five times the maximum circuit voltage or per paragraphs 6.2.2.1 or 6.2.2.2 whichever applies. The potential shall start from zero and be increased at a uniform rate to its test value. It shall be maintained at this value for five seconds, and then reduced at a uniform rate to zero.

Since these tests are intended to insure proper electrical isolation of the circuit components in question, these tests shall not be applied to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc.

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- 6.2.2.1 Hermetically sealed instruments shall be tested at 200 volts RMS.
- 6.2.2.2 Circuits that operate at potentials below 15 volts and contain low voltage elements such as transistors, diodes, capacitors and special signal generators are not to be subjected to overpotential tests.
- 6.3 Position Error: The change in pointer indication with change in instrument position from normal position shall not exceed 25 RPM.

- 6.4 Sealing: This test shall apply to hermetically sealed instruments only. The indicator shall be immersed in a suitable liquid, such as water. The absolute pressure of the air above the liquid shall then be reduced to approximately 1 inch of mercury and maintained for 1 minute, or until air bubbles substantially cease to be given off by the liquid, whichever is longer. The absolute pressure shall then be increased to 2-1/2 inches Hg. Any bubbles coming from within the indicator case shall be considered as leakage and shall be cause for rejection. Bubbles which are the result of entrapped air in the various exterior parts of the case shall not be considered as a leak.

A helium leak detector or other means of test, equal or superior in sensitivity to the immersion method described above, may be used. Where a leak detector is employed for conducting the test, the leak rate shall not exceed 1 micro-cubic foot per hour at a pressure differential of approximately 1 atmosphere.

If the indicator incorporates non-hermetically sealed attachments, such as a case extension, these components may be removed prior to the Sealing Test.

7. QUALIFICATION TESTS: As many instruments as may be deemed necessary to demonstrate that all instruments will comply with the requirements of this section shall be tested in accordance with the manufacturer's recommendations.
- 7.1 Low Temperature: The instrument shall be subjected to -30C for three hours. The change in indication from the reading obtained at room temperature shall not exceed one percent of full scale. The instrument may be operated at 2000 RPM or half scale, whichever is higher, for a period of 10 minutes before making this scale error test. The force required to turn the generator shaft while and after it has been subjected to a temperature of minus 55C for two hours, shall not exceed 8 pound inches. No damage to the generator shall result from this test.
- 7.2 High Temperature: The instrument shall be subjected to a temperature of 70C for a period of three hours. The change in indication from the readings obtained at room temperature shall not exceed one percent of full scale for the range 600-2800 RPM and shall not exceed one and one-half percent of full scale for the range 3000 to 4500 RPM.

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- 7.3 Extreme Temperature Exposure: The instrument shall, after alternate exposure to ambient temperatures specified in Column B of Section 3.3.1 for a period of 24 hours each and a delay of 3 hours at room temperature following completion of the exposure, meet the requirements of Section 6.1. During the high temperature exposure, the generator shall be operating at a shaft speed equivalent to half-scale indicator reading and shall be supplying full-rated electrical load for that speed. There shall be no evidence of damage as a result of exposure to the extreme temperatures specified herein.
- 7.4 Magnetic Effect; The magnetic effect of the indicator shall be determined in terms of the deflection of a free magnet, approx. 1-1/2 inches long, in a magnetic field with a horizontal intensity of 0.19 ± 0.01 gauss when the indicator is held in various positions on an east-west line with its nearest part 12 inches from the center of the magnet. This test shall first be made with the indicator not operating and then shall be repeated with the indicator in normal operation. The maximum deflection of the free magnet shall not exceed 5 degrees for any pointer or dial position.
- 7.5 Vibration:
- 7.5.1 Resonance: The instrument, while operating and with various pointer settings throughout the range, shall be subjected to a resonant frequency survey of the appropriate range specified in Section 3.3.3 in order to determine if there exists any resonant frequencies of the parts. The amplitude used may be of any convenient value that does not exceed the maximum double amplitude and the maximum acceleration specified in Section 3.3.3.

The instrument shall then be subjected to vibration at the appropriate double amplitude or maximum acceleration specified in Section 3.3.3 at the resonant frequency for a period of one hour in each axis or with circular motion vibration whichever is applicable. When more than one resonant frequency is encountered with vibration applied along any one axis, a test period may be accomplished at the most severe resonance, or the period may be divided among the resonant frequencies, whichever shall be considered most likely to produce failure. The test period shall not be less than one-half hour at any resonant mode. When resonant frequencies are not apparent within the specified frequency range, the instrument shall be vibrated for two hours in accordance with the vibration requirements schedule, Section 3.3.3, at the maximum double amplitude and the frequency to provide the maximum acceleration.

While the instrument is being vibrated, the pointer oscillation shall not exceed one percent of full scale indication. The average pointer variation during vibration shall not exceed one percent of full scale indication. After these observations have been made, the vibration stand shall be set as indicated above and operated for the remainder of the two hour test period with the pointer position changed every twenty to thirty minutes.

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- 7.5.2 Cycling: The instrument, while operating shall be tested with the frequency cycled between the limits specified in Section 3.3.3 in 15 minute cycles for a period of one hour in each axis at an applied double amplitude specified in Section 3.3.3, or an acceleration specified in 3.3.3 whichever is the limiting value, or a total of three hours for circular motion vibration, whichever is applicable. The pointer position shall be changed every twenty to thirty minutes during this test.

After the completion of this vibration test, the "Scale Error at Room Temperature" test in Section 6 shall be repeated. No damage shall be evident and the change in indication between this test and the initial room temperature scale error test shall not exceed one percent of full scale indication.

- 7.6 Humidity: This test shall not apply to hermetically sealed indicators. The indicator and generator shall be mounted in the normal operating position and maintained at a temperature of $70 \pm 2^\circ\text{C}$ and a relative humidity of $95 \pm 5\%$ for a period of 6 hours. After this period the heat shall be shut off and the instrument shall be allowed to cool for a period of eighteen hours in this atmosphere in which the humidity rises to 100% as the temperature decreases to not more than 38°C . This complete cycle shall be conducted:

- a. Five times for instruments located in uncontrolled temperature areas.
- b. Once for instruments located in controlled temperature areas.

Immediately after cycling, the indicator shall be subjected to the "Scale Error Test at Room Temperature" of Section 6. The change in reading between this test and the original scale error at room temperature test shall not exceed 10 RPM.

The performance of the generator shall not be adversely affected as a result of this humidity cycling.

- 7.7 Acceleration Endurance: The generator drive shaft and rotor shall be subject to a uniform acceleration of 400 revolutions per second per second for a period of at least five seconds. The generator shall be subjected to this acceleration for 500 applications. No damage to any part of the generator shall result from this test.
- 7.8 Thermal Shock: This test shall apply to hermetically sealed instruments only. The indicator shall be subjected to four cycles of exposure to water at $85 \pm 2^\circ\text{C}$ and $5 \pm 2^\circ\text{C}$ without evidence of moisture penetration or damage to coating or enclosure. Each cycle of the test shall consist of immersing the indicator in water at $85 \pm 2^\circ\text{C}$ for a period of 30 minutes, and then within 5 seconds of removal from the bath, the indicator shall be immersed for a period of 30 minutes in the other bath maintained at 5°C . This cycle shall be repeated continuously, one cycle following the other until four cycles have been completed. Following this test, the indicator shall be subjected to the Sealing test specified in 6.4. No indicator leakage shall occur as a result of this test.

Prepared by SAE Committee A-4, Aircraft Instruments